MASTER OF SCIENCE IN MECHANICAL ENGINEERING

MODELING THE EFFECT OF CYCLING OF A LOCALIZED HEAT SOURCE IN THE DIE OF A FLIP CHIP PACKAGE WITH DEFECTS

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In this study,the finite element based numerical tool ANSYS was used to perform a nonlinear transient coupled-field thermal and structural analysis on a flip chip package. The effect of cycling of a localized source of heat, the die was studied in order to determine the possible formation of hot spots in a flip chip package with conduction inhibiting defects such as imperfect contact between the bump and pad. Different heat source levels and defect severities (characterized by reduced bump pad conductivities) were analyzed by subjecting the package to two step-change thermal cycles for each case studied. The thermal results indicate significant temperature differences within the package in all cases thus pointing to the need for a non-isothermal analysis. The structural results indicate a seemingly anomalous behavior of increased cycles to failure with increasing power and severity of defect which can be explained by the rapidly varying nature of the stresses thus resulting in minimal creep damage.

MODELING THE BIODYNAMICAL RESPONSE OF THE HUMAN HEAD FOR INJURY ANALYSIS

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The objective of this study is to develop a finite element model of the human head and neck to investigate the biomechanics of head injury. The finite element model is a two-dimensional, plane strain representation of the cervical spine, skull, and major components of the brain including the cerebrum, cerebellum, brain stem, tentorium and the surrounding cerebral spinal fluid. The dynamic response of the model is validated by comparison with the results of human volunteer sled acceleration experiments conducted by Ewing et al. To validate the head model, one of the head impact experiments performed on cadavers by Nahum et al. is simulated. The model responses are compared with the measured cadaveric test data in terms of head acceleration, and intracranial pressures measured at four locations including the coup and contrecoup sites. The validated model is used to demonstrate that the Head Injury Criterion (HIC), which is based on resultant translational acceleration of the center of gravity of the head, does not relate to the various mechanisms of brain injury and is therefore insufficient in predicting brain injury.

SEMI-RIGID TOWING MODEL FOR ANALYSIS OF MANUEVERING IN THE HORIZONTAL PLANE

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A SIMULINK towing model is developed from the surge, sway, and yaw equations of motion in order to study the horizontal maneuverability of vessels in a semi-rigid towing operation. This analysis is conducted in order to validate rigid-connection towing and to give insight into the design of the tow connector. The connection is modeled as a linear spring and the maneuverability of the vessels is studied as the stiffness is varied from conditions of semi to completely rigid. This study is based on two Swath hull vessels, the *SLICE* and *KAIMALINO*, towing in close proximity under calm water conditions.

COUPLED LAGRANGIAN AND EULERIAN APPROACH TO DETONATION AND FRAGMENTATION PROBLEMS

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Many obstacles such as minefields, barbwire entanglements, tank ditches and other fortifications are used to paralyze the forward momentum of mechanized armed forces. To combat this the Grizzly tracked vehicle was developed for the United States Army. Due to the Grizzly's mission various sensors; laser systems, hydraulic lines, wires and cameras are mounted on the armor hull, which are exposed to various types of landmine detonation and fragmentation. This thesis studies the effects of shock waves and fragmentation on the survivability of the equipment mounted on the Grizzly's armored hull. Models of an OZM-72 antipersonnel mine are developed and used to simulate the detonation and fragmentation phenomena. The analysis results obtained from the models provide a basis from which design guidance can be formulated for protecting equipment or personnel from this threat.

AN EXPERIMENTAL INVESTIGATION OF THE BOW WAVE ON *USS COLE* (DDG-67)

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This is an experimental investigation into the formation of the bow wave on *USS COLE* (DDG-67) and her 1/250 scale model. The experiment examines the bow wave from a hydrodynamic signature point of view. Previous experiments have looked at the phenomenon from an icing, deck wetness or hull resistance standpoint. Very little research has emphasized the importance to the Navy of the effects of the bow wave and subsequent spray on the overall radar cross-section and stealth of the vessel. Measurements were conducted on a 1/250-scale model and compared to video of the *USS COLE* (DDG-67) wherever possible. The effects of steady, heave, pitch and combinations of heave and pitch motions were studied to quantify the base flow in comparison to the *USS COLE*. The Froude Number for the majority of the work was 0.25. Model scale frequencies ranged from 1 to 5 Hz, pitch angles from 0.85 degrees to 3.75 degrees and heave amplitudes from 1/8 to 1/2 of an inch. This research, coupled with subsequent studies of sheet separation and a physics based understanding of all the mechanisms, is essential to developing a numerical model that could begin to predict the basics of the highly complex bow wave and spray region.

VALIDATION OF LOW OBSERVABLE STACK EDUCTOR DESIGN FOR GAS TURBINE EXHAUST SYSTEMS

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An experimental and analytical program was conducted to improve the entrainment performance of a low aspect ratio mixing tube (about unity) eductor. A new primary flow pattern, consisting of eight high aspect ratio, pie-shaped nozzles, was designed to increase mixing and product better outlet flow uniformity. The aerodynamic performance of the new design was measured in a 1/5 scale, cold-flow facility, and the results compared to a nozzle plate with 16 constant-width, radial nozzles. Experimental results are presented for a range of conditions and include the effects of mixing tube misalignment and inlet blockage. The new nozzle is shown to increase the secondary pumping ratio by 7%. In addition, a one-dimensional, steady, analytical model of an educator, which includes frictional losses and outlet momentum non-uniformity is presented. The model predicts the performance of real eductors to within 3% and shows that the momentum non-uniformity is the primary factor limiting performance.

A FINITE ELEMENT ANALYSIS OF THERMAL FATIGUE STRESSES IN THE SOLDER JOINTS OF A FLIP CHIP PACKAGE

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A nonlinear finite element model was created using ANSYS to analyze the deformation and stresses in the solder bumps of a flip chip package subjected to thermal cycling. A parametric study of the effects of different dwell times, temperature ranges, and ramp rates in a thermal fatigue cycle was conducted for two different package geometries. The goal of this study was to use an energy density damage analysis to investigate the reliability (in cycles to failure) of a typical flip chip package by examining critical solder bump stress-strain behavior due to thermal cycling. The creep damage mechanism was found to be the primary mode of failure, which severely limited package life. A concurrent study of the behavior of the package with and without underfill showed that the bumps surrounded by under fill experienced considerably lower creep damage due to increased hydrostatic stresses, which in turn significantly extended the life of the package.